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Soviet Battlefield Lasers: Emerging Threat of Blinding and Antisensor Weapons [redacted])

A Technical Intelligence Report

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September 1987

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Soviet Battlefield Lasers: Emerging Threat of Blinding and Antisensor Weapons [redacted]

A Technical Intelligence Report

This paper was prepared by [redacted]
Office of Scientific and Weapons Research.
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[redacted] OSWR, [redacted]

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Soviet Battlefield Lasers: Emerging Threat of Blinding and Antisensor Weapons [redacted]

Key Judgments

Information available as of 30 June 1987 was used in this report.

Soviet and Warsaw Pact low-energy laser rangefinders and laser target designators pose a significant blinding threat—out to several hundred meters—to US and NATO soldiers. Several tens of thousands of such systems are deployed. The most serious danger of blinding is to the soldier or pilot using magnifying optics, such as binoculars or those optics found in tank, antitank guided-missile launchers, or helicopter fire-control systems. Low-energy laser rangefinders, although not intended for blinding, can have their energy magnified through these optical systems and cause blindness. [redacted]

In addition to this existing threat, we believe with high confidence that the Soviets will also field dedicated laser blinding and antisensor weapons. Because we lack sufficient information about their design specifications, we remain uncertain when these weapons will become operational. [redacted]

Western soldiers in combat, if left unprotected against these laser blinding weapons, probably will suffer a significant number of eye casualties. Such injuries could range from temporary incapacitating flashblindness to total blindness in both eyes. Furthermore, sensitive electro-optic systems, if not incorporated with protective filters, probably will be damaged and their performance severely degraded. Compared with a laser rangefinder or target designator, a dedicated laser weapon would be a significantly greater threat, with the ability to produce severe eye injury out to several kilometers. It would be designed to acquire high-speed targets more rapidly, to track them more accurately, and to attack them with greater lethality at long ranges. [redacted]

We conclude that the Soviets are developing and probably intend to field dedicated blinding and antisensor weapons. [redacted]

- [redacted] the Soviets have used low-power laser devices on several occasions since the 1970s to irradiate Western personnel on reconnaissance.
- [redacted] Warsaw Pact writings [redacted] discuss the development of a new tactical doctrine, called "opto-electronic warfare," to use lasers against Western visual and electro-optical sensors.

- The Soviet military has funded research for over 25 years on laser-induced eye damage in support of a laser blinding weapons development program.
- [redacted] senior Soviet military officials have stated [redacted] that the use of lasers as tactical weapons in the near future is inevitable.
- [redacted] the Soviets are developing tactical laser blinding weapons that should reach initial operational capability (IOC) no later than the mid-1990s.
- Soviet laser technology probably has been sufficiently mature for over a decade to support the development of a laser blinding weapon.
- Sufficient production capability exists within the laser and electro-optical production facilities of the Soviet military-industrial ministries to meet the series-production requirement for a laser blinding weapon [redacted]

If the Soviets have already fielded or will soon field an antisensor laser weapon, we believe it would:
- Be basically an "upgrade" of existing military laser systems.
- Incorporate a design that emphasizes minimal technological risk—that is, one based on proven laser technology available to the Soviets in the mid-to-late 1970s.
- Have a significant tactical capability, probably emitting a visible or near-infrared beam of a few tens-of-watts average power.

[redacted]

On the other hand, the Soviets may choose—or may already have chosen—to field a more capable laser blinding weapon, one whose complexity requires a dedicated vehicle. We believe that a Soviet laser blinding and antisensor weapon incorporated into a dedicated vehicle would be much more powerful. It probably would involve a significantly greater technological risk than one based on proven "off-the-shelf" technology for which such key issues such as series producibility and system reliability are

known. For this type of system, we project an IOC in the early-to-middle 1990s. [redacted]

[redacted]

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Introduction

The next war will be won by the side which best exploits the electromagnetic spectrum.

Adm. Sergey Gorshkov
Commander in Chief, Soviet Navy

Morskoy Sbornik, June 1974

This report assesses Soviet intentions to develop and use lasers as blinding and antisensor weapons. These lasers are not laser rangefinders and target designators. They are designed specifically to blind enemy soldiers and pilots and to damage or disrupt electro-optical sensors. This paper also assesses the supporting Soviet research, development, testing, and evaluation (RDT&E) effort directed at developing such laser weapons for use on the battlefield. [redacted]

Lasers could easily be used as blinding weapons. Eyes and electro-optical sensors can be saturated or damaged very easily when illuminated by a laser's very-bright-light source. For example, if a visible laser irradiates an eye for only a millionth of a second and delivers only 25 millionths of a joule of energy, it can produce catastrophic eye injury resulting in permanent blindness. By contrast, a laser would have to deliver several million times as much energy to damage the aluminum or titanium skin of a fighter aircraft. [redacted]

[redacted] The Soviets have deployed low-energy lasers as adjuncts to tanks, aircraft, and other weapon systems. They will be used, at least, in target rangefinding, target designation, and decoying US laser-guided munitions away from their targets. Soviet tank laser rangefinders emit approximately three times more energy per pulse than Western tank laser rangefinders. This is enough energy to degrade significantly an enemy soldier's or pilot's ability to maintain precise fire control of his weapon systems. Also, this level could produce severe eye damage at tactically significant ranges. Target designators are more hazardous than laser rangefinders. They typically emit 10 to 20 pulses per second—only one of which is needed to cause severe eye damage—and are aimed and fired at targets for periods up to several tens of seconds. [redacted]

Soviet weapons designed specifically to blind people or damage sensors would provide a much more significant threat than currently fielded laser rangefinders and laser target designators. Table 1 compares the blinding potential of currently fielded Soviet laser rangefinders and target designators versus a dedicated laser blinding weapon. [redacted]

Soviet Intentions To Use Lasers for Blinding

[redacted] the Soviets have used lasers against enemy soldiers and pilots. We believe this indicates a continuing Soviet interest in the utility of lasers for blinding personnel and disrupting electro-optical reconnaissance activity:

- [redacted] the Soviets have used lasers to blind enemy soldiers in combat.

Table 1
Blinding Potential of Soviet Laser Rangefinders and Target Designators Versus Likely First-Generation Laser Blinding Weapons

	Probability of Severe Eye Injury [a]					
	500 Meters		2 Kilometers		5 Kilometers	
	Using 7x Binoculars	Not Using Binoculars	Using 7x Binoculars	Not Using Binoculars	Using 7x Binoculars	Not Using Binoculars
Current threat systems						
Tank laser rangefinder (T-72 and T-80) [b]	0.30	0.03	0.00	0.00	0.00	0.00
Airborne laser target designator (for example, KLEN) [c]	0.85	0.33	0.00	0.00	0.00	0.00
Future threat systems [d]						
Crew-served laser blinding weapon [e]	1.00	1.00	0.99	0.94	0.22	0.05
Laser blinding weapon requiring a dedicated vehicle [f]	1.00	1.00	1.00	1.00	1.00	1.00

[a] The probability assumes injury following exposure to one laser pulse under early morning or early evening (that is, "mesoptic") conditions. A severe eye injury is defined as one in which retinal edema (localized swelling) and necrosis (cell death) occur immediately following exposure to a laser, equivalent to a "Grade II" retinal injury. (A Grade II injury occurs when an exposure is approximately 20 times more intense than the maximum permissible level of exposure.) Although the injury is considered severe because of the ocular pathology that occurs, a degradation in performance of important tasks that require good visual acuity (for example, precise fire control or the piloting of a high-performance aircraft) can occur at much lower exposure levels; that is, when no or only minimal ocular injury occurs.

[b] T-72 and T-80 tank laser rangefinders are assumed to have the following characteristics: wavelength = 1.06 micrometers; pulse energy = 100 millijoules; pulse width = 50 nanoseconds (at one-half maximum amplitude); pulse repetition frequency = 1 hertz; and beam divergence = 300 microradians.

[c] Soviet airborne laser target designators are assumed to have the following characteristics: wavelength = 1.06 micrometers; pulse energy = 300 millijoules; width = 50 nanoseconds; pulse repetition frequency = 20 hertz; and beam divergence = 300 microradians. Because of the higher pulse repetition rate, it is probable that a soldier or pilot will be exposed to more than one pulse, increasing the probability that he will suffer a severe eye injury.

[d] The characteristics of the "future systems" is for illustrative purposes only. [redacted] however, the lasers described here are well within Soviet capabilities.

[e] The crew-served or man-portable laser blinding weapon is assumed to incorporate a laser that emits a visible beam with the following characteristics: wavelength = 532 nanometers; pulse duration = 50 nanoseconds; pulse repetition frequency = 10 hertz; pulse energy = 1 joule; and beam divergence = 100 microradians.

[f] The laser-blinding weapon in a dedicated vehicle is assumed to incorporate a 100-watt, repetitively pulsed (5.5 millijoule x 18 kilohertz) neodymium laser, mounted in an ACRV-M 1974-type armored vehicle [redacted] It may emit either a visible or near-infrared laser beam.

[redacted]

- [redacted] the Soviets have used and are continuing to use lasers to harass Western military liaison missions and reconnaissance assets. [redacted]
- [redacted] the Warsaw Pact is developing a tactic to use lasers for blinding. [redacted]

Soviet Use of Lasers in Combat To Blind the Enemy

[redacted]

[redacted]

[redacted]

Soviet Use of Lasers Against Western Tactical Reconnaissance Assets

The Soviets over the past 10 years have directed potentially hazardous, low-power laser beams at [redacted] US tactical reconnaissance assets. Such actions convince us that the Soviets intend to use lasers to harass, damage, or injure US and Western visual and electro-optical reconnaissance assets, including personnel. [redacted]

[redacted]

Soviet "Opto-Electronic Warfare": An Evolving Tactic

Numerous Soviet open-source military publications emphasize the use of lasers and noncoherent (nonlaser) infrared equipment to disrupt or suppress the

[redacted]

optical and electro-optical sensors of Western reconnaissance equipment and precision-guided munitions. The Soviets call this practice "opto-electronic warfare," a form of radioelectronic combat (REC). As an example, [redacted] Warsaw Pact writings [redacted] discuss the lessons learned from field exercises and describe REC for motorized rifle and tank divisions. Lasers and noncoherent infrared equipment are mentioned within the context of REC. [redacted]

Soviet Research Applicable to a Laser Blinding Weapon Program

The Soviets have placed a high priority on military-related laser research since the invention of the laser in 1960. Good evidence exists that they have studied and are continuing to study the use of lasers to blind enemy soldiers and to degrade optical and electro-optical sensors. This evidence can be conveniently divided into the following lines of thought:

- The Soviets maintain a significant commitment of resources—facilities, manpower, equipment, and funding—to develop laser technology and to design systems.
- Soviet laser and associated electro-optical technologies are sufficiently mature to design and build laser blinding and antisensor weapons.
- The Soviet military has funded for over 25 years a research program to study laser-induced eye damage.
- The Soviet military-industrial optical production plants have sufficient production capacity to series produce a tactical laser weapon. [redacted]

Resource Commitment

The Soviet military maintains an extensive RDT&E infrastructure for laser technology development and laser systems design activity. A large part of this effort is for research in support of strategic applications (for example, antisatellite [ASAT] and ballistic missile defense). We believe, however, that a significant portion exists for research in support of tactical applications. [redacted]

An important gauge of the Soviet level of effort on laser weapons is the resources that have been expended. [redacted]

Technology Maturity

One of the key issues concerning the use of lasers for blinding and sensor damage is the maturity of laser and related technologies (for example, optics, power supply, and pointing and tracking). Although the Soviets would begin the preliminary design of a laser weapon system after the key technologies have proved feasible, they will not enter into full-scale system engineering design work until the key technologies are considered mature. The Soviets consider that a given technology is mature when it has achieved pilot production. [redacted]

Table 2
Soviet Lasers With a Potential for Use as Tactical Blinding or Antisensor Weapons

Type	Dominant Wavelength(s) (*micrometers*)	Efficiency (*percent*)	Technical Maturity (*date*)	Comments
Ruby	0.6943 (red)	<1	Early-to-middle 1960s	First fielded by the Soviets in 1969 as an artillery laser rangefinder (LRF); in-band to the eye.
Neodymium	1.064 (near-IR), 1.060 (near-IR), 0.532 (green)	1 to 5	Early 1970s	Neodymium lasers used in Soviet tank LRFs; though Nd lasers emit in the near-IR, they are considered in-band to the eye since it is focused on the retina.
Carbon-dioxide	10.6 (far-IR)	Up to 30	Mid-to-late 1970s	In-band to FLIR systems.
Argon-ion	0.488 (blue), 0.514 (blue-green)	<0.1	Mid-1970s	Emits many wavelengths in the ultraviolet and visible; in-band to the eye. Soviets developed a powerful 500-watt argon laser in early 1970s.
Dye	Tunable in the visible	0.4 (flashlamp pumped) Up to 25 (laser pumped)	Mid-1970s (dye in liquid); Late 1980s (dye in solid matrix)	Emits throughout the visible and near-IR; in-band to the eye; dyes bleach out with continuous pumping (that is, limited lifetime).
Copper vapor	0.510 (green), 0.578 (yellow)	1	Late 1970s to early 1980s	This is a gas laser; in-band to the eye. Researchers at TsKB Luch are known to be working on copper vapor lasers.
Alexandrite	Tunable in the near-IR	Up to 6	Mid-to-late 1980s	This solid-state, tunable laser emits in the visible and near-IR. It currently is in production in the Soviet Union.
Color-center	Tunable in the near-IR	Up to 40	Late 1980s	Soviets first reported room temperature operation in 1978.

[redacted]

[redacted] Without exception, studies have shown that Soviet laser technology and the appropriate supporting technologies have been sufficiently mature since approximately the mid-to-late 1970s to begin engineering development of tactical laser weapons.[1] [redacted]

We believe that several Soviet laser technologies were sufficiently mature by the mid-to-late 1970s for blinding and antisensor weaponry applications. Visible lasers, which emit in the visible and near-infrared (near-IR) portion of the spectrum, would be appropriate for use against direct-view optics, human eyes, and image intensifiers. Neodymium lasers technology is probably the most mature technology in this class. Other mature visible or near-IR technologies include ruby, argon, dye, copper vapor, and alexandrite. Carbon dioxide lasers, which emit in the far-IR portion of the spectrum at 10.6 micrometers, would be most appropriate for degrading or even damaging forward-looking infrared (FLIR) systems and for burning the cornea of the eye or a soldier's skin. FLIR systems operate in the 8 to 12 micrometers (thermal) portion of the spectrum (see table 2). [redacted]

[redacted]

[redacted]

[redacted]

Series-Production Capability

A necessary condition—[redacted] for the full-scale engineering development of a new weapon is the existence of a production capability

[redacted]

for the system. [redacted]

The Ministry of Defense Industry (MOP) has the primary responsibility for design and production of Soviet electro-optical and laser systems and armor systems. As such, it would be the defense-industrial ministry responsible for the design, testing, and production of a mobile (that is, vehicle-mounted) laser blinding weapon. [redacted]

Laser Weapons Programs: Technology Development, Weapon Development, or Both?

[redacted]

[redacted]

[redacted]

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[redacted]

Threat Projection

[redacted] we believe [redacted] that the Soviets eventually will field a dedicated laser blinding and antisensor weapon. We are uncertain, however, when such a weapon will be fielded. [redacted]

[redacted]

A Low-Risk Design: A Near-Term Possibility
If the Soviets have already fielded or will soon field a blinding or antisensor laser weapon, we believe it would incorporate a design that emphasizes low technological risk—that is, technology roughly equivalent to that available in the mid-to-late 1970s. It would probably be the small, man-portable or tripod-mounted weapon or adjunct weapon referred to above. It would have a limited though significant tactical capability, probably emitting a repetitively pulsed, visible, or near-infrared beam up to a few tens-of-watts average power with a blinding range probably out to a

couple of kilometers against the unaided eye. Even when deployed, the presence of such a weapon in the hands of the troops would probably be extremely difficult for us to detect. [redacted]

A High-Risk Design: Probably an IOC in the Early-to-Middle 1990s

On the other hand, the Soviets may decide, or have already decided, to build the much more capable weapon system, the one involving greater technological risk referred to above. This weapon, compared with the low-risk design, would have much higher average power and better pointing-and-target-tracking capability. The key to an accurate projection of this type of system lies, as we noted above, in interpreting correctly Soviet laser RDT&E activity; namely, determining when the Soviets transitioned or will transition from NIR to OKR. We believe that Soviet laser technologies relevant to a higher risk antisensor or blinding weapon reached sufficient maturity probably by the mid-1970s to support the beginning of an OKR program. If we are correct in assessing when the relevant laser technology reached sufficient maturity, then it is possible that an OKR weapons design program could have begun as early as the late 1970s. More probably, the program began in the early 1980s. Assuming that the OKR program proceeds on schedule and requires eight to 10 years, then:

- If the OKR start date is in the early 1980s—which we believe to be the most probable start time—we project the Soviets will achieve an IOC for the weapon in the early-to-middle 1990s.
- If the OKR start date was the late 1970s—which we see as a lower probability—we project the Soviets could be close to an IOC for the weapon at the present time, that is, the late 1980s.
- If the OKR start date is in the late 1980s—which we see as the lowest probability—we project that the Soviets will achieve an IOC for the weapon in the late 1990s. A weapon program begun in the late 1980s may incorporate a tunable laser. A tunable laser would emit laser radiation at any of several wavelengths, severely complicating US efforts to incorporate eye and sensor protection. [redacted]

It is possible, though we believe unlikely, that the deployment of a Soviet laser blinding weapon is imminent (that is, in the mid-to-late 1980s). On the other hand, we believe that it is highly probable that the Soviets will eventually field a laser blinding weapon—one incorporated into a dedicated vehicle—most likely in the early-to-middle 1990s. [redacted]

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